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Feasibility Impact Analysis Report
Surface Vessel Bilgewater/Oil Water Separator

Section 7.0 – WHEC 378 Class: High Endurance Cutter Vessels that Process Bilgewater and Dirty Ballast

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SECTION 7.0 – WHEC 378 CLASS

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7.0 WHEC 378 CLASS

The U.S. Coast Guard's HAMILTON Class (WHEC 378) of high endurance cutters was selected to represent the group of vessels that use diesel engines for main propulsion and process both bilgewater and dirty ballast through their oil water separator (OWS). The WHEC 378 Class vessels are powered by diesel and gas turbine engines (CODOG – combined diesel or gas turbine). Each vessel in this class generates approximately 5,835 gallons of bilgewater within 12 nautical miles (nm) and approximately 27,750 gallons of bilgewater beyond 12 nm annually. The total volume of bilgewater generated within 12 nm is calculated by adding the volume of bilgewater generated in port to the volume generated while operating within 12 nm (e.g., steaming within 12 nm that occurs while transiting out to 12 nm). WHEC 378 Class vessels spend approximately 166 days pierside and another 14 days operating within 12 nm of shore, for a total of 180 days within 12 nm of shore annually (Navy and EPA, 2003). WHEC 378 Class vessels operate approximately 185 days beyond 12 nm of shore (Navy and EPA, 2003). The in-port bilgewater generation rate is 22.5 gallons per day (gpd), and the underway (both transiting and beyond 12 nm) rate is 150 gpd (Navy and EPA, 2003).

Bilgewater generated within 12 nm:

$$\frac{166 \text{ days (pierside)}}{\text{yr}} \bullet \frac{22.5 \text{ gal}}{\text{day}} + \frac{14 \text{ days (underway)}}{\text{yr}} \bullet \frac{150 \text{ gal}}{\text{day}} = 5{,}835 \text{ gal/yr}$$

Bilgewater generated beyond 12 nm:

$$\frac{185 \text{ days}}{\text{yr}} \bullet \frac{150 \text{ gal}}{\text{day}} = 27{,}750 \text{ gal/yr}$$

WHEC 378 Class vessels use a 44 gallons per minute (gpm) HELI-SEP 10000B gravity coalescence type OWS to process bilgewater; consequently this option is referred to as the current marine pollution control device (MPCD). The WHEC 378 Class vessels operate one 100-gpm pump to offload oily wastewater and one 30-gpm pump to offload waste oil (Volpe, 2001). WHEC 378 Class vessels are unique in that they use their OWSs to process both bilgewater and dirty ballast water. Dirty ballast water is the seawater added to fuel tanks to replace the fuel consumed by the engines in order to maintain the stability of the vessel. The use of the OWSs to process dirty ballast necessitates the consideration of MPCDs of sufficient capacity to process both bilgewater and dirty ballast water. However, maintenance requirements and costs were calculated using only bilgewater generation rates. The maintenance requirements and cost associated with processing dirty ballast will be addressed in the Dirty Ballast Feasibility Impact Analyses Report.

To the extent possible, the current MPCD was used to select the capacities and quantities of each MPCD evaluated in the feasibility analysis. The following MPCDs are evaluated in this feasibility analysis for WHEC 378 vessels: gravity coalescence, centrifuge, collection, holding, and transfer (CHT), evaporation, hydrocyclones, *in situ* biological treatment, oil absorbing socks, filter media, and membrane filtration.

7.1 GRAVITY COALESCENCE

The following sections discuss the feasibility and cost impacts of installing and operating a gravity coalescence unit on-board a WHEC 378 Class vessel.

7.1.1 Practicability and Operational Impact Analysis

This section describes the analyses of specific feasibility criteria relative to the physical characteristics and operational requirements of gravity coalescence units.

7.1.1.1 Space and Weight

As described in section 7.0, the analysis of gravity coalescence will include one 44-gpm gravity coalescence unit and one 30-gpm waste oil offload pump. The gravity coalescence OWS installed on-board these vessels is intended for single-deck operation and is commonly placed in main or auxiliary machinery spaces, in the vicinity of the oily waste holding tank (OWHT). Table 7-1 provides the space and weight for the HELI-SEP 10000B.

Table 7-1. HELI-SEP 10000B Specifications (WHEC 378 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	44 gpm	4.9 x 4.2 x 6.3	7.3 x 7.3 x 7.3	130	1400/4300
Total (To achieve required processing capacity)	1	44 gpm	-	-	130	1400/4300

Clearance is required above the OWS tank assembly to mount chain falls for the removal of the tank cover.

7.1.1.2 Personnel/Equipment Safety

There are no unusual personnel or equipment safety hazards associated with gravity coalescence units. Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use on-board vessels of the Armed Forces. Standard control and management procedures are adequate for use and disposal of this material. While gravity coalescence units require electrical power, existing standard shipboard safety procedures for handling electrical equipment have been adequate to protect personnel and safety.

7.1.1.3 Mission Capabilities

The use of these units on WHEC 378 Class vessels has not resulted in any impact on ship's signature, war-fighting capabilities, mobility, or on any mission critical systems or operations.

7.1.1.4 Personnel Impact

The HELI-SEP 10000B separator runs in automatic mode, but requires general supervision while the unit is operating. Based on a bilgewater processing rate of 44 gpm and the approximate 5,835 gallons of bilgewater generated annually within 12 nm, the number of hours the gravity coalescer is operated annually within 12 nm is approximately 2 hours.

$$\frac{5{,}835 \text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{44 \text{ gal}} \bullet \frac{\text{hr}}{60 \text{ min}} = 2.2 \text{ hrs/yr}$$

Based on operational experience, the time required per year to supervise the operation of the HELI-SEP 10000B separator is approximately 0.25 hours (15 minutes) for every two hours the unit operates. The supervisory labor requirement of 0.25 hours for every two hours of operation is based on the assumption that although the unit is automatic, a crewmember will be assigned to general oversight of multiple pieces of equipment at once. Based on an annual operating requirement of 2.2 hours, the annual labor requirement associated with the operation of a gravity coalescence unit within 12 nm is .28 hours, as calculated below:

$$\frac{2.2 \text{ hr}}{\text{yr}} \bullet \frac{0.25 \text{ hours labor}}{2 \text{ hr}} = 0.28 \text{ hours labor/yr}$$

In addition, the waste oil removed from the bilgewater must be transferred to a shore facility. This transfer requires three crewmembers per event. One crewmember is required to operate the waste oil transfer pump and associated valves and hull connections. A second crewmember is required to oversee the connection of transfer hoses for the offloading vessel. A third crewmember oversees the connection of transfer hoses for the receiving vessel or facility. The two crewmembers overseeing the transfer hose connections are on standby in case the connections separate. The two crewmembers also ensure that appropriate precautions are taken to prevent oil spills. During waste oil transfer activities, two-way voice communication is established between the three crewmembers overseeing the oil transfer (Navy, 2002). The labor hours associated with transferring the waste oil produced by a gravity coalescence unit on the WHEC 378 are calculated by dividing the waste oil volume (1 percent of the bilgewater volume generated annually within 12 nm) by the waste oil pump rate and multiplying by the number (three) of crew members.

$$\frac{58.35 \text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{30 \text{ gal}} \bullet \frac{\text{hr}}{60 \text{ min}} \bullet \frac{3 \text{ hours labor}}{\text{hr}} = 0.097 \text{ hours labor/yr}$$

The combined annual labor associated with operating a gravity coalescence unit within 12 nm and transfer of waste oil transfer of waste oil generated within 12 nm on a WHEC 378 Class vessel is 0.37 hours.

The total labor requirement associated with vessel operation beyond 12 nm includes MPCD operator oversight (i.e., 15 minutes for every two hours of equipment operation) and labor required to oversee the offloading of waste oil to shore attributable to vessel operation beyond 12 nm. The annual labor requirement associated with operating this MPCD beyond 12 nm is calculated using the same methodology used to calculate the annual labor requirement within 12 nm. The volume (i.e., 27,750 gal) of bilgewater generated beyond 12 nm and resultant volume (i.e., 277.5 gal) of waste oil that requires offloading to shore are based on the WHEC 378 Class vessel underway bilgewater generation rate of 150 gpd. The underway generation rate is multiplied by the number of days (185 days) spent beyond 12 nm. Hours of MPCD operation and annual labor requirements are presented below.

Hours of MPCD operation beyond 12 nm:

$$\frac{27{,}750\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{44\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} = 11\text{ hrs/yr}$$

Labor requirement for MPCD operator oversight:

$$\frac{11\text{ hrs}}{\text{yr}} \bullet \frac{0.25\text{ hours labor}}{2\text{ hrs}} = 1.3\text{ hr labor/yr}$$

Labor requirement for offloading waste oil:

$$\frac{277.5\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{30\text{ gal}} \bullet \frac{\text{hr}}{60\text{min}} \bullet \frac{3\text{ hours labor}}{\text{hr}} = 0.46\text{ hours labor/yr}$$

Total MPCD operator labor and waste oil offloading oversight associated with the operation of a HELI-SEP 10000B on a WHEC 378 Class vessel beyond 12 nm is 1.8 hrs/yr.

Annually, the HELI-SEP 10000B requires approximately 12.7 personnel hour of time-based maintenance, 6.25 personnel hours of condition-based maintenance within 12 nm, and 0 personnel hours of condition-based maintenance beyond 12 nm. Table 7-2 and Table 7-3 summarize the time-based and condition-based maintenance requirements, respectively, for one HELI-SEP 10000B separator (Bindal, 2000a).

Table 7-2. HELI SEP 10000B Time-Based Maintenance (WHEC 378 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Inspection and Replacement of Anodes	3	3 months	12
Motor Lubrication	1	18 months	0.67
Total Annualized Hours (per unit)	-	-	12.67
Total Annualized Hours (total)	-	-	12.67

Table 7-3. HELI SEP 10000B Condition-Based Maintenance (WHEC 378 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on .45 operation hours within 12 nm)	Annualized Maintenance Hours (based on 1.8 operation hours beyond 12 nm)
Cleaning the Supply Strainer	0.25	As Needed*	0.25	0
Replacement of Pump Mechanical Seal	6	As Needed*	6	0
Total Annualized Hours (per unit)	-	-	6.25	0
Total Annualized Hours (total)	-	-	6.25	0

**For calculations it was assumed that the condition-based maintenance was performed annually.*

Table 7-4 provides the annual labor hours required to operate and maintain gravity coalescence.

Table 7-4. Gravity Coalescence Annual Labor Hours (WHEC 378 Class)

	Gravity Coalescence
Operator Hours Within 12 nm	0.37
Operator Hours Beyond 12 nm	1.8
Condition-based Maintenance Within 12 nm	6.25
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance	12.67
Total Time	21.1

7.1.1.5 Consumables, Repair Parts, and Tools

Gravity coalescence units installed on WHEC 378 Class vessels do not require consumables. No special tools are required for the operation or maintenance of these units.

7.1.1.6 Interface Requirements

Table 7-5 provides the specific system interface requirements associated with the WHEC 378 OWS (Bindal, 2000a).

Table 7-5. HELI-SEP 10000B Interface Requirements (WHEC 378 Class)

Shipboard System	HELI-SEP 10000B Interface Requirements
Electrical Power	440V/3PH/60Hz, Motor – 1.5 HP
Seawater (via auxiliary seawater supply)	1 inch, 150 lb flange connection
Drainage	1 inch, 150 lb flange connection

7.1.1.7 Control System Requirements

The gravity coalescence units installed on-board WHEC 378 Class vessels are designed to operate in either automatic or manual mode. Automatic operation is the normal operating mode. Units have a flow sensor that will secure the system if the pump loses suction and a remote alarm/indicator panel that allows shipboard personnel to monitor the operating status of the units while in the automatic mode of operation. The remote alarm/indicator contains visual indicators that allow operating personnel to monitor the overall status of the system and an audible alarm that warns of system malfunction.

In addition, HELI-SEP 10000B units are equipped with an oil content monitor (OCM) to measure the oil content of OWS effluent. If the OCM detects an oil concentration greater than the predetermined desired concentration, the OCM will direct the effluent back to the OWHT to be processed again by the OWS.

7.1.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

7.1.2 Cost Analysis

The following cost data and calculations are provided to allow the reader to compare relative costs associated with a gravity coalescence system on a WHEC 378 Class vessel.

7.1.2.1 Initial Cost

There are no initial costs associated with using gravity coalescence on a WHEC 378 Class vessel because the equipment is in place as described above.

7.1.2.2 Recurring Cost

Personnel Labor Within 12 nm

This MPCD requires 19.29 personnel hours per year for operation, condition-based maintenance, and time-based maintenance within 12 nm as explained under Section 7.1.1.4. The number of annual labor hours multiplied by the $22.64 hourly MPCD operator labor rate produces the annual recurring labor cost within 12 nm.

$$\frac{\$22.64}{\text{hr labor}} \bullet \frac{19.29 \text{ hr labor}}{\text{yr}} = \$437/\text{yr}$$

Personnel Labor Beyond 12 nm

This MPCD requires 1.8 personnel hours per year for operation beyond 12 nm, as explained under Section 7.1.1.4. The annual labor cost associated with operating this MPCD beyond 12 nm is calculated using the same hourly labor rate used to calculate the annual labor cost within 12 nm, as shown below.

$$\frac{\$22.64}{\text{hr labor}} \bullet \frac{1.8\text{ hr labor}}{\text{yr}} = \$40/\text{yr}$$

The labor required to transfer waste oil generated by the gravity coalescence system to a disposal activity is included in the above labor cost estimates.

Coast Guard vessels pay a fee to dispose of their waste oil. The recurring cost incurred by the Coast Guard to dispose of the waste oil generated within 12 nm is shown below.

$$\frac{58.35\,\text{gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$53/\text{yr}$$

The recurring cost incurred by the Coast Guard to dispose of waste oil generated beyond 12 nm is shown below.

$$\frac{277.5\,\text{gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$253/\text{yr}$$

Table 7-6 summarizes the annual recurring costs for a gravity coalescer system used on a WHEC 378 Class vessel.

Table 7-6. Annual Recurring Costs for Gravity Coalescence (WHEC 378 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Coast Guard	0.490
Beyond 12 nm	Coast Guard	0.293

7.1.2.3 Total Ownership Cost (TOC)

Table 7-7 summarizes the TOC and annualized cost over a 15-year lifecycle for a gravity coalescer system on a WHEC 378 Class vessel.

Table 7-7. TOC for Gravity Coalescence (WHEC 378 Class)

Cost ($K)	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	0	0
Total Recurring	5.46	3.25
TOC (15-yr lifecycle)	5.46	3.25
Annualized	.464	.277

7.2 CENTRIFUGE

The following sections discuss the feasibility and cost impacts of installing and operating a centrifuge on-board WHEC 378 Class vessels.

7.2.1 Practicability and Operational Impact Analysis

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of centrifuges.

7.2.1.1 Space and Weight

One 50-gpm (WSC-50) centrifuge unit is proposed in this analysis. The unit was chosen because it has an equivalent processing capacity of the current MPCD in place on WHEC 378 Class vessels. The units are manufactured by a major supplier of centrifuges used in the marine industry and are representative in space, weight, and power requirements of centrifuges with similar processing capacities. Table 7-8 provides the space and weight for a centrifuge, which comes as a complete modular unit (includes one 50-gpm centrifuge and heater).

Table 7-8. WSC 50 Specifications (WHEC 378 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	50 gpm	6 x 8 x 8.2	7.75 x 10 x 9.2	393	6610/7385
Total (To achieve required processing capacity)	1	50 gpm	6 x 8 x 8.2	7.75 x 10 x 9.2	393	6610/7385

The centrifuge is designed for single deck operation. The existing OWS unit would be removed and replaced with the centrifuge module in the same location.

7.2.1.2 Personnel/Equipment Safety

Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use on Armed Forces vessels. Standard afloat control and management procedures are adequate for use and disposal of the material. While centrifuges require electrical power, observing standard shipboard safety procedures for handling electrical equipment should be adequate.

7.2.1.3 Mission Capabilities

The installation and operation of a centrifuge on WHEC 378 Class vessels are not expected to have an impact on ship’s signature, mobility, or on any mission critical systems or operations.

7.2.1.4 Personnel Impact

The WSC 50 centrifuge separator runs in automatic mode, but requires general supervision while the unit is operating. Based on a MPCD rated capacity of 50 gpm and the approximate 5,835 gallons of bilgewater generated annually, the number of hours the centrifuge would be operated within 12 nm is 1.9 hours.

$$\frac{5{,}835\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{50\text{ gal}} \bullet \frac{\text{hr}}{60\text{min}} = 1.9\text{ hr /yr}$$

The labor requirement for general oversight of the centrifuge system is calculated as 0.25 hours for every two hours of operation. The supervisory labor requirement of 15 minutes for every two hours of operation is based on the assumption that although the unit is automatic, a crewmember will be assigned to general oversight of multiple pieces of equipment at once. Therefore the annual labor requirement associated with the operation of a centrifuge within 12 nm is 0.24 hours.

$$\frac{1.9\text{ hr}}{\text{yr}} \bullet \frac{0.25\text{ hr labor}}{2\text{ hr}} = 0.24\text{ hr labor/yr}$$

In addition, the waste oil removed from the bilgewater must be transferred to a shore facility. This transfer requires three crewmembers per event as described under Section 7.1.1.4. The labor hours associated with transferring the waste oil produced within 12 nm of shore is calculated by dividing the waste oil volume (1 percent of the annual bilgewater volume generated while operating within 12 nm of shore) by the waste oil pump rate and multiplying by the number (three) of crewmembers.

$$\frac{58.35\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{30\text{ gal}} \bullet \frac{\text{hr}}{60\text{min}} \bullet \frac{3\text{ hours labor}}{\text{hr}} = 0.097\text{ hours labor/yr}$$

The combined annual labor associated with the operational oversight of the centrifuge unit within 12 nm and transfer of waste oil generated within 12 nm on a WHEC 378 Class vessel is .34 hours.

The total labor requirement associated with vessel operation beyond 12 nm includes MPCD operator oversight (i.e., 15 minutes for every two hours of equipment operation) and labor required to oversee the offloading of waste oil to shore attributable to vessel operation beyond 12 nm. The annual labor requirement associated with operating this MPCD beyond 12 nm is calculated using the same methodology used to calculate the annual labor requirement within 12 nm. Hours of MPCD operation and annual labor requirements are presented below.

Hours of MPCD operation beyond 12 nm:

$$\frac{27{,}750\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{50\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} = 9.3\text{ hr /yr}$$

Labor requirement for MPCD operator oversight:

$$\frac{9.3\text{ hrs}}{\text{yr}} \bullet \frac{0.25\text{ hr labor}}{2\text{ hr}} = 1.2\text{ hours labor/yr}$$

Labor requirement for offloading waste oil:

$$\frac{277.5\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{30\text{ gal}} \bullet \frac{\text{hr}}{60\text{min}} \bullet \frac{3\text{ hour labor}}{\text{hr}} = 0.46\text{ hours labor/yr}$$

Total MPCD operator labor and waste oil offloading oversight associated with a WSC 50 centrifuge on a WHEC 378 Class vessel beyond 12 nm is 1.6 hour per year.

Annually, the WSC 50 requires approximately 19.75 personnel hours of time-based preventive maintenance per year, 0 personnel hours of condition-based maintenance within 12 nm, and 0 personnel hours of condition-based maintenance beyond 12 nm. Table 7-9 and Table 7-10 summarize the time-based and condition-based maintenance requirements, respectively, for one WSC 50 centrifuge.

Table 7-9. WSC 50 Time-Based Maintenance Requirements (WHEC 378 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Change gear case oil.	1	6 months	2
Remove, clean, and grease bowl lock ring, and re-install it.	1	6 months	2
Grease motor bearings.	0.25	12 months	0.25
Inspect and clean bowl: Remove bowl top. Clean sludge space and disks as required. If the bowl is removed during this procedure, ensure that the spindle cone and bowl nave is clean, dry, and free of grease.	2	3 months	8
Check starting time. Check thickness of clutch shoe linings. Replace as necessary.	0.25	6 months	0.5
Check thickness of brake lining. Replace as necessary.	0.5	12 months	0.5
Check foundation bolts for proper tensioning. Check all readily accessible equipment bolts and fasteners for proper tension.	0.5	12 months	0.5
Check shock mounts for cracks, peeling of rubber, or any distortions. Replace as necessary.	0.25	12 months	0.25
Check to ensure that a clearance of 3 mm between the decelerator unit and ship's foundation is correct.	0.25	12 months	0.25
Replace Ball bearings on spindle	1	12 months	1
Replace Ball bearings on worm wheel shaft	1	6 months	2
Check pump strainer. Clean as required.	0.25	6 months	0.5
Check water strainer(s). Clean as required.	0.25	6 months	0.5
Check to make sure operating water feeding device is not plugged.	0.25	6 months	0.5
Check and tighten system hardware including all foundations	1	12 months	1

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Check motor winding resistance.	0.5	12months	0.5
Check operation of pressure switch. Repair or replace as required.	0.25	6 months	0.5
Total Annualized Hours (per unit)	-	-	20.75
Total Annualized Hours (System)	-	-	20.75

Table 7-10. WSC 50 Condition-Based Maintenance (WHEC 378 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on 2 operation hours within 12 nm)	Annualized Maintenance Hours (based on 10 operation hours beyond 12 nm)
None	0	0	0	0
Total Annualized Hours (per unit)	-	-	0	0
Total Annualized Hours (total)	-	-	0	0

Centrifuges are equipped with programmable logic controls and monitoring systems. The oil content monitor alarm can be monitored remotely or locally.

Operator certification is not required. Inexperienced equipment operators require four to six hours of training. Properly operating centrifuges pose no impact on habitability.

Table 7-11 provides the annual labor hours required to operate and maintain the WSC 50 centrifuge unit.

Table 7-11. Centrifuge Annual Labor Hours (WHEC 378 Class)

	MPCD Option: (WSC 50) (hours/unit)
Operator Hours Within 12 nm	0.34
Operator Hours Beyond 12 nm	1.6
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance	20.75
Total Time	22.7

7.2.1.5 Consumables, Repair Parts, and Tools

Centrifuges require consumables and special tools. In addition, a spare parts kit is available from the vendor. Consumables include items such as filters, gaskets, “O” rings, and bearings. The special tools required are delivered with the machine and consist of spanner wrenches made specifically for dismantling the purifier bowl.

7.2.1.6 Interface Requirements

Table 7-12 lists the interfaces required to support each WSC 50 centrifuge module.

Table 7-12. WSC 50 Interface Requirements (WHEC 378 Class)

Shipboard System	WSC 50 gpm (per unit)
Electrical Power	440VAC/3PH, 80-130kW
Compressed Air	0.0045-0.022scfm 0.0058 - 0.029cfm @ 50 psig
Potable Water	50 gpd, 45 psi
Drainage	Gravity drain to OWHT

The WHEC 378 Class vessels are able to support these requirements.

7.2.1.7 Control System Requirements

Based on the manufacturer’s recommendations, the operator manually turns on the equipment. However, once the centrifuge has reached its operating speed, the WSC 50 does not require constant oversight (Donohue, 1999).

A centrifuge would be equipped with an OCM to measure the oil content of OWS effluent. If the OCM detects an oil concentration greater than a predetermined concentration, the OCM will direct the effluent back to the OWHT to be processed again by the OWS.

7.2.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

7.2.2 Cost Analysis

The following cost data and calculations are provided to allow the reader to compare relative costs associated with a centrifuge system on a WHEC 378 Class vessel.

7.2.2.1 Initial Cost

The centrifuge system procurement cost is $452,000 (Donohue, 2000). Based on previous ship check of USCGC GALLATIN (a WHEC 378 Class vessel), the installation of the centrifuge unit will cost $169,000 (Navy, 2000). The installation would require approximately 4 weeks to complete. Technical manuals cost approximately $85,000 ($7,100 per vessel) to develop a 150-page manual (Gallagher, 1999). The development of technical drawings will cost $31,000

($2,600 per vessel) (Navy, 2000). The cost for training materials is approximately $9,330 ($777 per vessel) (Smith, 2001). The total initial cost of a centrifuge system on a WHEC 378 Class vessel is $632,000.

7.2.2.2 Recurring Cost

Personnel Labor Within 12 nm

This MPCD requires 21 personnel hours per year for operation and time-based maintenance within 12 nm, as explained in Section 7.2.1.4. The number of annual labor hours multiplied by the $22.64 hourly MPCD operator labor rate produces the annual recurring labor cost within 12 nm, as shown below.

$$\frac{\$22.64}{\text{hr labor}} \bullet \frac{21\ \text{hr labor}}{\text{yr}} = \$477/\text{yr}$$

Personnel Labor Beyond 12 nm

This MPCD requires 1.6 personnel hours per year for operation beyond 12 nm, as explained under Section 7.2.1.4. The annual labor cost associated with operating this MPCD beyond 12 nm is calculated using the same hourly labor rate used to calculate the annual labor cost within 12 nm, as shown below.

$$\frac{\$22.64}{\text{hr labor}} \bullet \frac{1.6\ \text{hr labor}}{\text{yr}} = \$37/\text{yr}$$

The labor required to transfer waste oil generated by the centrifuge system to a disposal activity is included in the above labor cost estimates.

Coast Guard vessels pay a fee to dispose of their waste oil. The recurring cost incurred by the Coast Guard to dispose of the waste oil generated within 12 nm is shown below.

$$\frac{58.35\ \text{gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$53/\text{yr}$$

The recurring cost incurred by the Coast Guard to dispose of waste oil generated beyond 12 nm is shown below.

$$\frac{277.5\ \text{gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$253/\text{yr}$$

Table 7-13 summarizes the annual recurring costs for centrifuges used on a WHEC 378 Class vessel.

Table 7-13. Annual Recurring Costs for Centrifuge (WHEC 378 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Coast Guard	.531
Beyond 12 nm	Coast Guard	.289

7.2.2.3 Total Ownership Cost (TOC)

Table 7-14 summarizes the TOC and annualized cost over a 15-year lifecycle for a centrifuge system on a WHEC 378 Class vessel.

Table 7-14. TOC for Centrifuge (WHEC 378 Class)

Cost ($K)	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	632	632
Total Recurring	5.65	3.02
TOC (15-yr lifecycle)	637	635
Annualized	54	53.9

7.3 COLLECTION, HOLDING, AND TRANSFER (CHT)

The following sections discuss the feasibility and cost impacts of not discharging bilgewater (treated or untreated) from WHEC 378 Class vessels to the environment within 12 nm from shore. This no-discharge option is referred to as the practice of CHT. The bilgewater may be transferred to shore facilities in port or discharged overboard in accordance with applicable regulations beyond 12 nm from shore.

7.3.1 Practicability and Operational Impact Analysis

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of CHT.

7.3.1.1 Space and Weight

WHEC 378 Class vessels are equipped with a series of OWHTs that have a combined design capacity of approximately 3,500 gallons. The holding tank is designed with capacity that is 5 percent in excess of the ship’s requirements to minimize the risk of overfilling the tank, which would result in spillage. However, common practice throughout the Coast Guard is to limit the maximum volume of bilgewater to approximately 70 percent of design capacity (2,450 gallons). This allows for a margin of safety to accommodate the following scenarios without jeopardizing vessel safety or vessel mission/operations: 1) unexpected surges in bilgewater production due to minor flooding; 2) changes in vessel mission/operations that would temporarily prohibit the operation of the OWS for periods up to 48 hours; and 3) 48 hour margin in case of an OWS casualty. This tank is designed to collect and hold oily waste (i.e., bilgewater) for processing by the vessel’s 44-gpm OWS unit or for transfer to shore, as applicable. As such, WHEC 378 Class vessels are capable of practicing CHT up to the existing holding capacity without experiencing any impacts to space and weight. The potential for exceeding the vessel's existing space and weight capacities, as a result of practicing CHT, will depend upon the length of time spent within 12 nm from shore, and whether the port visited has the capability to offload wastewater.

During a typical operating cycle, WHEC 378 Class vessels may visit many ports for varying lengths of time. The WHEC 378 Class typically operates their OWS units rather than offloading their bilgewater to shore. The longest stays in port tend to be at the vessel's homeport or at other major Coast Guard ports, where extensive shore services, including oily wastewater offloading, are available. The Coast Guard uses commercial contractors to provide wastewater-offloading facilities (i.e., tank trucks). To support their operational requirements (e.g., search and recovery missions, drug traffic interdiction, etc.), WHEC 378 Class vessels may also visit smaller ports where offloading services are not available. In this situation, a WHEC 378 Class vessel could be required to collect and hold all bilgewater generated until the ship is beyond 12 nm. The following paragraphs will evaluate three potential scenarios: (1) arriving at a port where wastewater offloading services are available, (2) arriving at a port where such services are not available, and (3) vessel operations within 12 nm of shore.

Ports with wastewater offloading services: The WHEC 378 Class vessels are homeported in Honolulu, HI; Charleston, SC; Alameda, CA; San Pedro, CA; San Diego, CA. and Seattle, WA. These are all major ports with complete shore services, including wastewater offloading. Once a vessel has docked at one of these ports, the transfer of bilgewater to shore can be performed as needed. WHEC 378 Class vessels can also collect and hold bilgewater generated while transiting from 12 nm to port for transfer shoreside. With the exception of Seattle, WA, all of the homeports are on the coast, where it takes two or three hours to transit between port and 12 nm from shore. For WHEC 378 Class vessels homeported in Seattle, WA, it can take up to six hours to transit between port and 12 nm from shore. Therefore, the transit to Seattle represents the maximum extent of transit duration. While underway, WHEC 378 Class vessels generate approximately 150 gpd of bilgewater, or six gallons per hour. Using a generation rate of six gallons per hour over six hours, the maximum volume of bilgewater generated would be approximately 36 gallons. Transits to ports other than Seattle, WA will take less time and result in lower volumes of bilgewater generation. Because the 36 gallons collected during transit is well within the holding capacity for WHEC 378 Class vessels, practicing CHT while transiting to or from a port with offloading facilities will not have space or weight impacts.

Ports without wastewater offloading services: If a vessel is visiting a port where offloading bilgewater is not possible, the ship could be required to hold all bilgewater during the entire time spent within 12 nm. A typical visit to a small port may last two to five days. Assuming a five-day port visit, a WHEC 378 Class vessel would generate approximately 113 gallons of bilgewater (based on in port generation rate). Using a generation rate of six gallons per hour and a total transit time of six hours (three hours for the transit in and out of port), the vessel would generate an additional 36 gallons of bilgewater while transiting to and from port. The total bilgewater generated within 12 nm from shore would be 149 gallons. This is within the current safe holding capacity of the existing OWHTs; therefore, practicing CHT in this scenario should not result in any space or weight impacts. Under this scenario, a WHEC 378 Class vessel could practice CHT for five days without exceeding the existing holding capacity.

Vessel operations within 12 nm of shore: Due to the nature of some U.S. Coast Guard missions, a WHEC 378 Class vessel may be required to operate within 12 nm from shore for an extended period of time (up to 60 days) without returning to port (Volpe, 2000c). Based upon a generation rate of 150 gpd and a designed holding capacity of 2,450 gallons, a WHEC 378 Class vessel can operate up to 16 days without exceeding its designed holding capacity. After 16 days, it would not be possible for a WHEC 378 Class vessel to comply with a no-discharge requirement without expanding the bilgewater holding capacity. Using the OWS to process bilgewater from the bilge area as it is generated would decrease the OWS effectiveness. The OWHT acts as a pretreatment that allows the oil content to settle out of the bilgewater allowing the OWS to operate more effectively. Also, the Coast Guard tries to maintain operational flexibility by keeping, at a minimum, 30 percent of the OWHT empty at all times. The bilgewater content of the tanks would therefore be processed by the OWS once the tanks were 70 percent full.

Practicing CHT within the existing holding capacity will not result in any space or weight impacts. While the above analyses describe typical operating scenarios, there may be situations where practicing CHT may exceed the vessel's existing holding capacity. Extra tank capacity would be required to accommodate any additional volume of bilgewater collected. This would result in space and weight impacts. Because the space and weight allocations on WHEC 378 Class vessels are tightly controlled, there is generally very little unassigned space to accommodate additional tankage. Therefore, the most likely strategy for increasing bilgewater holding capacity would be to convert other existing tanks to bilgewater holding tanks. However, converting existing tanks to hold bilgewater would likely result in adverse impacts to those systems or services that rely on the tanks to be converted for holding oily waste.

7.3.1.2 Personnel/Equipment Safety

Practicing CHT within the vessel's existing holding capability will not pose any safety hazards to the vessel's crew or equipment.

7.3.1.3 Mission Capabilities

Practicing CHT within the vessel's existing holding capacity will not have an impact on ship's signature, war fighting capabilities, mobility, or on any mission critical systems or operations.

Ship designers review the ship's requirements (i.e., vessel's range, number of crew, etc.) to determine the tank capacities needed to allow the ship to fulfill its mission. With the exception of approximately five percent excess capacity as a margin of safety, ship designers do not size a vessel's tank capacity beyond what is necessary to meet the ship's requirements. Practicing CHT in excess of the vessel's existing holding capability would likely require that additional tanks be built or tanks used for other purposes be converted to bilgewater holding tanks. Reducing the capacity of existing tanks (such as potable water tanks or sewage tanks) to increase bilgewater holding capacity will reduce the ship's current capability to support its mission.

The Coast Guard mission often requires their vessels to operate for extended periods of time within 12 nm (e.g., search and rescue missions). The Coast Guard may operate their OWS, as necessary and at the discretion of the Commanding Officer, to prevent bilgewater accumulation in excess of the vessels' current holding capacity and minimize mission impacts. In instances where a Coast Guard vessel is at risk of exceeding its bilgewater holding capacity (e.g., during extensive operations within 12 nm), requiring Coast Guard vessels to practice CHT without the flexibility of processing bilgewater through the OWS would have a significant mission impact. Specifically, if a Coast Guard vessel was required to practice CHT and was at risk of exceeding its current holding capacity, it would have to return to shore to offload bilgewater, thus forcing the vessel to discontinue critical mission-related activities.

7.3.1.4 Personnel Impact

Practicing CHT within the vessel's existing holding capacity will not result in any personnel impacts other than time required to oversee the transfer of bilgewater and oily waste to shore (see analysis below).

Practicing CHT as a primary control option does not require additional special training. Manning is required to oversee the transfer of bilgewater to a shore facility or receiving vessel (i.e., operate the oily waste transfer (OWT) pump and associated valves/hull connections). This transfer requires three crewmembers per event as described in the Section 7.1.1.4. The WHEC 378 Class vessel generates 5,835 gallons of bilgewater annually within 12 nm. The annual volume of bilgewater generated within 12 nm of shore divided by the OWT pump rate of 100 gpm multiplied by the number (three) of crewmembers required for oversight equals the personnel hours required per year for practicing CHT.

$$\frac{5{,}835 \text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{100 \text{ gal}} \bullet \frac{\text{hr}}{60 \text{ min}} \bullet \frac{3 \text{ hours labor}}{\text{hr}} = 2.9 \text{ hours labor/yr}$$

Table 7-15 provides the annual labor hours required for practicing CHT.

Table 7-15. CHT Annual Labor Hours (WHEC 378 Class)

	MPCD Option: CHT
Operator Hours Within 12 nm	2.9
Operator Hours Beyond 12 nm	0
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance Within 12 nm	0
Time-based Maintenance Beyond 12 nm	0
Total Time	2.9

WHEC 378 Class vessels are able to accommodate these interface requirements with no significant impact on existing systems.

7.3.1.5 Consumables, Repair Parts, and Tools

There are no requirements for consumables, repair parts, or tools associated with CHT.

7.3.1.6 Interface Requirements

Practicing CHT does not require any unique interface requirements. OWT pumps and associated valves, piping, and hull connections exist on this vessel class to support CHT.

7.3.1.7 Control System Requirements

There are no new automated control system requirements associated with CHT. However, crewmembers are required to watch for oily wastewater spills, as mentioned in Section 7.1.1.4.

7.3.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

7.3.2 Cost Analysis

The following cost data and calculations are provided to allow the reader to compare relative costs associated with practicing CHT on a WHEC 378 Class vessel. CHT is generally not practiced beyond 12 nm from shore; therefore, CHT costs are calculated for operation within 12 nm only. Vessels in this class will continue to comply with appropriate regulations when operating beyond 12 nm.

7.3.2.1 Initial Cost

As described in Section 7.3.1.3, the reallocation of tank space to increase bilgewater holding capacity on a WHEC 378 Class vessel cannot be accommodated due to the impact on mission capabilities and personnel. For the cost analysis, it was assumed that current bilgewater holding capacity is adequate. Therefore, the initial cost of acquisition and installation of additional equipment such as tankage and piping systems is assumed to be zero.

7.3.2.2 Recurring Cost

Practicing CHT requires 2.9 personnel hours per year for operation within 12 nm of shore, as explained under Section 7.3.1.4. The annual labor hours multiplied by the $22.64 per hour MPCD operator labor rate produces an annual labor cost of $66.

$$\frac{\$22.64}{\text{hr labor}} \bullet \frac{\text{2.9 hrs labor}}{\text{yr}} = \$66/\text{yr}$$

The annual bilgewater generation rate within 12 nm is 5,835 gallons. Multiplying the volume of bilgewater generated annually within 12 nm by the oily waste disposal cost produces an annual recurring disposal cost of $5,310.

$$\frac{5{,}835\,\text{gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$5{,}310/\text{yr}$$

Table 7-16 summarizes the annual recurring costs for practicing CHT on a WHEC 378 Class vessel.

Table 7-16. Annual Recurring Costs for CHT (WHEC 378 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	5.376
Beyond 12 nm	Navy	0

7.3.2.3 Total Ownership Cost (TOC)

Table 7-17 summarizes the TOC and annualized cost over a 15-year lifecycle for practicing CHT on a WHEC 378 Class vessel.

Table 7-17. TOC for CHT (WHEC 378 Class)

Cost ($K)	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	0	0
Total Recurring	59.89	59.89
TOC (15-yr lifecycle)	59.89	59.89
Annualized	5.09	5.09

7.4 EVAPORATION

Commercial evaporation units are designed to operate with fresh water waste streams (Navy and EPA, 2000b). To apply evaporation technology in a saltwater environment, design concerns such as corrosivity, plating out of salt in the unit, and buildup of salt and sludge would need to be addressed before this technology was considered feasible on this vessel class. The following analysis is provided to further qualify the feasibility of this MPCD.

As stated in Section 7.0, WHEC 378 Class vessels are equipped with one 44-gpm gravity coalescer OWS. Although this OWS processes bilgewater, it is sized to process dirty ballast quickly to avoid negative safety and operational impacts for these vessels. This OWS operates in batch mode (i.e., operates at maximum capability to eliminate accumulating bilgewater) to minimize the impact on the vessel's crew. A bilgewater evaporator with the maximum available processing rate, one gallon per minute, was chosen for this analysis. Each evaporator would require 162 kW of electrical power to operate; however, the WHEC 378 uses its total electrical capacity and there is no remaining service life (U.S. Coast Guard, 1989). The service life margin represents the total electrical capacity available to support additional electrical equipment following initial construction.

A significant amount of electrical power is required by Armed Forces vessels to support mission-related payloads such as the combat systems (e.g., weapons, command, communications, control, electronic warfare and countermeasures, etc.) and combat support and supply systems. Because the use of evaporators would exceed the vessel's total electrical capacity evaporation is not a feasible MPCD option group for WHEC 378 Class vessels.

7.5 HYDROCYCLONES

The following sections discuss the feasibility and cost impacts of installing and operating a hydrocyclone on-board a WHEC 378 Class vessel.

7.5.1 Practicability and Operational Impact Analysis

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of hydrocyclones.

7.5.1.1 Space and Weight

WHEC 378 Class vessels are equipped with a 44-gpm gravity coalescing type OWS. One 50-gpm hydrocyclone system is being proposed in this analysis. This unit was chosen because it has a similar processing capacity as the current MPCDs installed on WHEC 378 Class vessels and is representative in space, weight, and power requirements of hydrocylones with similar processing capacities. Table 7-18 provides the space and weight of a 50-gpm skid mounted model equipped with a strainer basket, helical rotor pump, 12-inch diameter vessel, and interconnecting piping.

Table 7-18. Hydrocyclone Specifications (WHEC 378 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	50 gpm	7 x 6 x 4	10 x 8 x 6	168	900/1000
Total (To achieve required processing capacity)	1	50 gpm	-	-	168	900/1000

The hydrocyclone modules are designed for single-deck operation and would be installed in the current OWS room. The existing OWS would be removed and replaced with the new hydrocyclone model.

7.5.1.2 Personnel/Equipment Safety

There are no unusual personnel or equipment safety hazards associated with hydrocyclones. Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use. Standard control and management procedures are adequate for use and disposal of the material. While hydrocyclones require electrical power, observing standard shipboard safety procedures for operating electrical equipment should be adequate.

7.5.1.3 Mission Capabilities

The installation and operation of hydrocyclones on WHEC 378 Class vessels are not expected to have an impact on ship's signature, war fighting capabilities, mobility, or on any mission critical systems or operations.

7.5.1.4 Personnel Impact

The hydrocyclone unit runs in automatic mode, but requires general supervision while the unit is operating. Based on a bilgewater processing rate of 50-gpm and the approximate 5,835 gallons of bilgewater generated annually within 12 nm, the hydrocyclone would be operated 1.9 hours annually within 12 nm.

$$\frac{5{,}835\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{50\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} = 1.9\text{ hrs/yr}$$

The labor requirement for general oversight of the hydrocyclone was estimated to be 0.25 hours (15 minutes) for every two hours of operation. The supervisory labor requirement of 15 minutes for every two hours of operation is based on the assumption that although the unit is automatic, a crewmember will be assigned to general oversight of multiple pieces of equipment at once. Therefore, the annual labor requirements associated with the operation of a hydrocyclone within 12 nm is 0.24 hours.

$$\frac{1.9\text{ hrs}}{\text{yr}} \bullet \frac{0.25\text{ hrs labor}}{2\text{ hr}} = 0.24\text{ hrs labor/yr}$$

In addition, the waste oil removed from the bilgewater must be transferred to a shore facility. This transfer requires three crewmembers per event as described under the Section 7.1.1.4. The labor hours associated with transferring the waste oil produced within 12 nm of shore are calculated by dividing the waste oil volume (one percent of the annual bilgewater volume generated while operating within 12 nm of shore) by the waste oil pump rate and multiplying by three crewmembers.

$$\frac{58.35\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{30\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{3\text{ hrs labor}}{\text{hr}} = 0.097\text{ hrs labor/yr}$$

The combined annual labor associated with the operational oversight of the hydrocyclone within 12 nm and the transfer of waste oil generated within 12 nm on WHEC 378 Class vessels is 0.34 hours.

The total labor requirement associated with vessel operation beyond 12 nm includes MPCD operator oversight (i.e., 15 minutes for every two hours of equipment operation) and labor required to oversee the offloading of waste oil to shore attributable to vessel operation beyond 12 nm. The annual labor requirement associated with operating this MPCD beyond 12 nm is calculated using the same methodology used to calculate the annual labor requirement within 12 nm. Hours of MPCD operation and annual labor requirements are presented below.

Hours of MPCD operation beyond 12 nm:

$$\frac{27{,}750\ \text{gal}}{\text{yr}} \bullet \frac{\text{min}}{50\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} = 9.3\,\text{hrs/yr}$$

Labor requirement for MPCD operator oversight:

$$\frac{9.3\ \text{hr}}{\text{yr}} \bullet \frac{0.25\ \text{hr labor}}{2\ \text{hr}} = 1.2\ \text{hrs labor/yr}$$

Labor requirement for offloading waste oil:

$$\frac{277.5\,\text{gal}}{\text{yr}} \bullet \frac{\text{min}}{30\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} \bullet \frac{3\,\text{hr labor}}{\text{hr}} = 0.46\ \text{hrs labor/yr}$$

Total MPCD operator labor and waste oil offloading oversight associated with the operation of this vessel class beyond 12 nm is 1.6 hrs/yr.

Annually, the hydrocyclone requires approximately 6.0 personnel hours of time-based maintenance, 0 personnel hours of condition-based maintenance within 12 nm, and 0 personnel hours of condition-based maintenance beyond 12 nm. Table 7-19 and Table 7-20 summarize the time-based maintenance and the condition-based maintenance requirements, respectively, for the hydrocyclone.

Table 7-19. Hydrocyclone Time-Based Maintenance (WHEC 378 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Clean and Inspect Strainer Basket	0.25	3 months	1
Open and Inspect Hydrocyclone Bundle	1	12 months	1
Inspect Positive Displacement Pump for Wear	1	18 months	.67
Rebuild Positive Displacement Pump Rotors	10	36 months	3.33
Total Annualized Hours (per unit)	-	-	6.0
Total Annualized Hours (total)	-	-	6.0

Table 7-20. Hydrocyclone Condition-Based Maintenance (WHEC 378 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on 1.7 operation hours within 12 nm)	Annualized Maintenance Hours (based on 10 operation hours beyond 12 nm)
None	0	0	0	0

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on 1.7 operation hours within 12 nm)	Annualized Maintenance Hours (based on 10 operation hours beyond 12 nm)
Total Annualized Hours (per unit)	-	-	-	0
Total Annualized Hours (total)	-	-	-	0

Table 7-21 provides the annual labor hours required to operate and maintain the proposed MPCD discussed in this section.

Table 7-21. Hydrocyclone Annual Labor Hours (WHEC 378 Class)

	MPCD Option: Hydrocyclone
Operator Hours Within 12 nm	0.34
Operator Hours Beyond 12 nm	1.6
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance Within 12 nm	6.0
Time-based Maintenance Beyond 12 nm	0
Total Time	8.0

Hydrocyclones do not have an impact on habitability. Hydrocyclones are closed systems, so no vapors are present. Manning requirements will be minimal because the hydrocyclones require very little maintenance, and operation can be fully automated. Periodic monitoring of the inlet and underflow pressures would be recommended to evaluate operating conditions and determine if maintenance is needed.

7.5.1.5 Consumables, Repair Parts, and Tools

Consumables and repair parts, which should be on hand, include “O” rings and gaskets for the cyclone vessel, a few spare cyclone liners, and some components (e.g. replacement diaphragm) for the pump.

7.5.1.6 Interface Requirements

Table 7-22 provides the specific system interface requirements associated with the hydrocyclones.

Table 7-22. Hydrocyclone Interface Requirements (WHEC 378 Class)

Shipboard System	50 gpm
Electrical Power	460VAC, 3 Phase, 60 Hz, 3.75 kW

WHEC 378 Class vessels are able to accommodate this interface requirement.

7.5.1.7 Control System Requirements

Hydrocyclones are generally designed to operate in either automatic or manual mode. Automatic operation is the normal operating mode. Units have a flow sensor that will secure the system if the pump loses suction and a remote alarm/indicator panel that will allow shipboard personnel to monitor the operating status of the units while in the automatic mode of operation.

7.5.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

7.5.2 Cost Analysis

The following cost data and calculations are provided to compare relative costs associated with a hydrocyclone system on a WHEC 378 Class vessel.

7.5.2.1 Initial Cost

The hydrocyclone system procurement cost is $62,000 (Benjamin, 2000). Installation cost includes the cost of labor, materials, and oversight to install the unit. Based on previous ship checks of USGC GALLATIN, the installation of the hydrocyclone system will cost $149,000 (Navy, 2000). The installation would require approximately four weeks to complete. Technical manuals cost approximately $85,000 ($7,100 per vessel) to develop a 150-page manual (Gallagher, 1999). The development of technical drawings will cost $23,000 ($1900 per vessel) (Navy, 2000). The cost of training materials includes the cost of development and implementation of a new module in an existing training course. The cost for training materials is approximately $9,330 ($777 per vessel) (Smith, 2001). The total initial cost of a hydrocyclone system on a WHEC 378 Class vessel is $220,000.

7.5.2.2 Recurring Cost

Personnel Labor Within 12 nm

This MPCD requires 6.3 personnel hours per year for operation and time-based maintenance within 12 nm, as explained under Section 7.5.1.4. The number of annual labor hours multiplied by the $22.64 hourly MPCD operator labor rate produces the first operating year recurring labor cost within 12 nm.

$$\frac{\$22.64}{\text{hr labor}} \bullet \frac{6.3 \text{ hrs labor}}{\text{yr}} = \$144/\text{yr (inside 12 nm)}$$

Personnel Labor Beyond 12 nm

This MPCD requires 1.6 personnel hours per year for operation beyond 12 nm, as explained under Section 7.5.1.4. The annual labor cost associated with operating this MPCD beyond 12 nm is calculated using the same hourly labor rate used to calculate the annual labor cost within 12 nm, as shown below.

$$\frac{\$22.64}{\text{hr labor}} \bullet \frac{1.6\ \text{hrs labor}}{\text{yr}} = \$37/\text{yr (outside 12 nm)}$$

The labor required to transfer waste oil generated by the hydrocyclone system to a disposal activity is included in the above labor cost estimates.

Coast Guard vessels pay a fee to dispose of their waste oil. The recurring cost incurred by the Coast Guard to dispose of the waste oil generated within 12 nm is shown below.

$$\frac{58.35\ \text{gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$53/\text{yr}$$

The recurring cost incurred by the Coast Guard to dispose of waste oil generated beyond 12 nm is shown below.

$$\frac{277.5\ \text{gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$253/\text{yr}$$

Table 7-23 provides the annual recurring costs for a hydrocyclone system used on a WHEC 378 Class vessel.

Table 7-23. Annual Recurring Costs for Hydrocyclone (WHEC 378 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	0.197
Beyond 12 nm	Navy	0.289

7.5.2.3 Total Ownership Cost

Table 7-24 summarizes the TOC and annualized cost for a 15-year lifecycle for a hydrocyclone system on a WHEC 378 Class vessel.

Table 7-24. TOC for Hydrocyclone (WHEC 378 Class)

Cost ($K)	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	220	220
Total Recurring	2.18	3.20
TOC (15-yr lifecycle)	222	223
Annualized	18.9	19.0

7.6 *IN SITU* BIOLOGICAL TREATMENT

In Situ biological treatment of bilgewater is the addition of microbes to a vessel's bilge spaces to digest its oil contents. For *in situ* biological treatment to be effective, the microbes must be left in the bilge for a sufficient period of time for this to occur. According to the vendor, the most effective use of *in situ* biological treatment is to leave the *in situ* material in the bilge spaces on the vessel for a 30-day period to establish a population of microbes (Opsanick, 2000). Transferring bilgewater to shore or allowing additional bilgewater to be introduced to the bilge spaces before the 30-day period is complete would decrease the *in situ* biological treatment's effectiveness. Due to the lack of performance data, the extent to which the effectiveness of biological treatment would be decreased cannot be determined (Opsanick, 2000). In addition, the vessel is continuously generating bilgewater during this period, which disrupts the batch process method recommended by the manufacturer. Therefore, *in situ* biological treatment is not a feasible MPCD option group for WHEC 378 Class vessels.

7.7 OIL ABSORBING SOCKS (OASS)

OASs are designed to absorb oil floating on the surface of a body of water (Sorbent Products, Inc., 2000). In this application, OASs would be placed inside the bilge areas of a WHEC 378 Class vessel to continuously absorb the waste oil from the bilgewater. When the OAS becomes fully saturated, they are manually removed and replaced with a new OAS. This use of OASs for WHEC 378 Class vessels poses concerns regarding its potential effects on emergency dewatering and its potential as a concentrated fuel source that could contribute to the intensity of an engine room fire.

The presence of OASs in the bilge spaces would potentially restrict the flow of bilgewater through the normal and emergency dewatering pumps and strainers by clogging the suction points. The use of OASs in the bilge spaces of both Coast Guard and Navy vessels would not be feasible due to vessel safety and survivability concerns. Both services prohibit (through practice) the presence of any loose materials or debris in the bilge areas that could potentially interfere with normal or emergency dewatering activities. Securing the OASs to a pipe or other type of fixture in the bilge would not resolve the potential interference of dewatering operations because the emergency situation (e.g., force of shock or explosion) requiring dewatering may dislodge the unit. Furthermore, the OAS still presents a concentrated fuel source for a fire that could contribute to the intensity of an engine room fire.

Based on the potential impacts related to emergency dewatering, and to potential fire hazards, OASs are not a feasible MPCD option group on WHEC 378 Class vessels.

7.8 FILTER MEDIA

Based on a review and analysis of the WHEC 378 Class arrangement drawings, the Navy's Alteration and Installation Team (AIT) has concluded that adequate space is not available on WHEC 378 Class vessels to accommodate a filter media system (Navy, 2000). Also, the OWS filter media polishing systems were installed on two DDG 51 Class destroyers and were removed because they failed to consistently produce an effluent with an oil content 15 parts per million or less (Hopko, 1996). Navy ships with OWSs and Oil Content Monitors should attempt to limit oil and oily discharges to 15 ppm oil worldwide (Navy, 2002). Therefore, use of filter media is infeasible and no further analysis will be conducted with regard to the use of filter media on WHEC 378 Class vessels.

7.9 MEMBRANE FILTRATION

Based on a review and analysis of the WHEC 378 Class arrangement drawings, the Navy's AIT has concluded that adequate space is not available on WHEC 378 Class vessels to accommodate an ultrafiltration membrane system (Navy, 2000). Therefore, use of membrane filtration is infeasible and no further analysis will be conducted with regard to the use of membrane filtration on WHEC 378 Class vessels.